[Authorized reprint from Vol. XXVI, No. 3 (July, 1909), of the Copyrighted PROCEEDINGS OF THE ENGINEERS' CLUB OF PHILADELPHIA.]

INDUSTRIAL PROGRESS OF MEXICO.

JOHN BIRKINBINE.
(Active Member.)

Read June 15, 1909.

SIXTEEN years ago it was my privilege to present before the Engineers' Club "Notes on Engineering in Mexico,"* in which were made comparisons of conditions noted during two professional visits to that country, in 1882 and 1893. The interval between these two visits covered the commercial awakening of Mexico, brought about largely by the construction of nearly 7000 miles of railroads in eleven years, but the changes then noted, although marked, were scarcely more pronounced than those evident during subsequent visits, and at the request of the Committee on Information the following data, gained by trips through our neighbor republic in 1905 and 1909, are offered to supplement the original paper.

It has not been my privilege to view Mexico as a tourist, and some features of especial historical or picturesque interest included in excursions are unfamiliar, for members of an organization of engineers know that business trips offer limited opportunities for sight-seeing. However, one short and four extended journeys in our neighboring republic included eighteen of the thirty-one political divisions, and, while many prominent cities and industrial centers are familiar, much of the country traversed has been away from railroad routes or established highways. During these journeys investigation of the resources of the country, the possibility of their exploitation, the industrial development, and the capabilities of the people have been studied.

The population has increased from 11,600,000 in 1890 to 15,500,000 (estimated) for 1908, and material advancement has outstripped the augmented population. Railroad extensions have opened areas of agricultural territory previously remote from markets where the products could be disposed of, and these avenues of traffic have made possible the exploitation of mines which otherwise would have lain dormant, while numerous industries, some on large scale, have been

* See PROCEEDINGS for July, 1893, vol. x, No. 3, pages 222 to 240.

established. Improved paving, water-supplies, and sewerage systems have added to the health and prosperity of cities, for although many ancient aqueducts are still in use, a number of these interesting examples of early engineering are abandoned because they supply water of undesirable quality or under insufficient head or in too limited quantity, and piping has been, or is being, substituted in modern water-supplies. Electricity has been liberally introduced as a source of light and power, many haciendas having individual generating plants and much of the

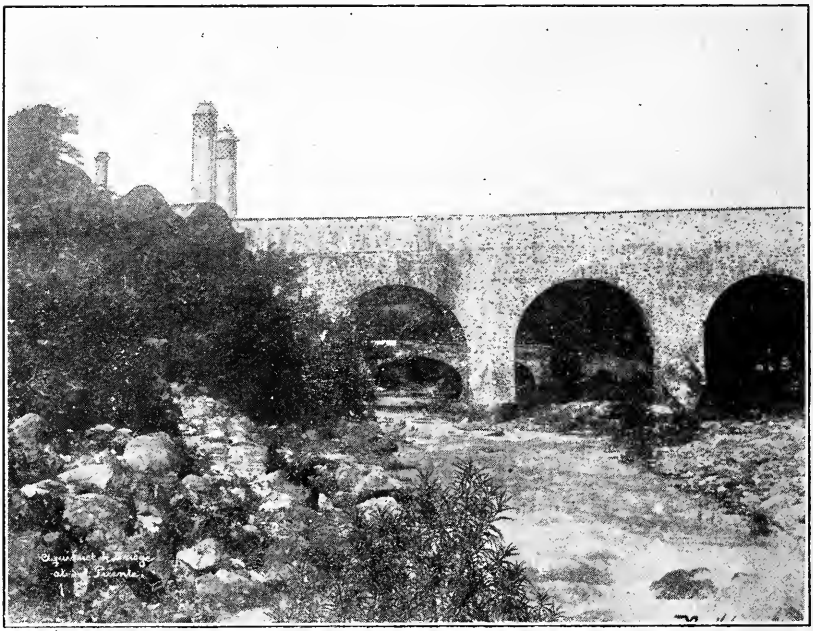

FIG. 1.—Masonry aqueduct and masonry bridge adjoining large hacienda in the State of Morelos, Mexico.

current being produced by hydro-electric installations, some of which are of phenomenal importance. The capital city is enjoying the advantage of the extensive drainage canal and tunnel referred to in 1893 as then under construction; its formerly dimly lighted streets and buildings are well illuminated by electricity, this same medium being applied to power purposes, and in a number of offices and homes electric heaters reduce the morning and evening chill which detracts so much from the comfort of visitors to this city of 450,000 inhabitants.

Foundations are engineering problems in the city of Mexico, as it is built on the remnant of a drained bog, and a prominent example is furnished by a monument on the "Paseo de la Reforma," which is now passing through the third effort to secure a stable base to support a tall shaft in a vertical position.

However, there are large buildings of steel skeleton construction with stone or brick face, such as market-houses, the "La Mutua" office building of five stories equipped with elevators, the new $5,000,000

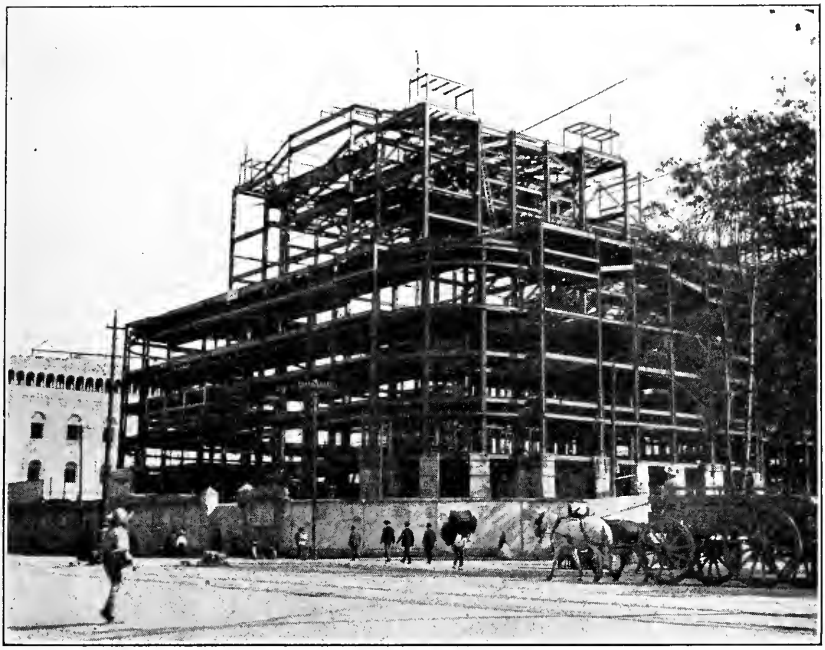

FIG. 2.—Steel skeleton structure of the National Theater in the City of Mexico. Note the heavy sections used.

theater now being erected, the skeleton being steel from Germany, and an interesting structure is the Geological Museum, with double spiral stairways of ornate design in metal.

To the boggy formation the residents of the city of Mexico attribute the moderate damage resulting from earthquakes, "temblores," for, while the wave motion is occasionally severe, the "wicked vertical shake" which demolishes buildings is moderated. There are several important structures much deformed from settlement, and one large

church decidedly out of plumb, which have withstood repeated shocks due to earthquakes that caused buildings to vibrate, high-tension feed wires to swing in contact so as to short circuit, and impelled the people to seek safety in open places.

A marked advance is in the urban and suburban traffic of the capital city, where the "cochero," who formerly by whip and whistle encouraged mules to draw small cars, is generally replaced by the motorman, who controls the operation of modern American-built trolley cars from overhead wires, but mule power transportation is prevalent in smaller cities.

The base of the statue erected on the Zocalo, a plaza of the City of Mexico, to commemorate the work of Enrico Martinez, the engineer who designed the drainage system, is utilized to exhibit the standard meter length, and on it is cut the latitude, 19° 28′ 4.5″ north; the longitude, 99° 6′ 42.6″ or 6h 38m 8.6s west from Greenwich; and the altitude above sea-level of 2269 meters, equivalent to 7439 feet. Mexican cartography, however, is usually referred to the meridian of the capital city.

The journey made in 1882 was in advance of railway construction, and tedious rides over alkali plains supporting only sage brush and cacti growth, or through rugged mountain passes, were made in "diligencias" or on horseback. Within late years these deserts have supplied "guayule," a formerly neglected plant, from the root and stems of which rubber is obtained. In 1904 "peons" were glad to collect this and pile it by the railroad for $8 to $10* (Mexican) per ton, for which service they now receive $34, and the large plants for treating it pay $70 to $75 per metric ton delivered. Botanists are studying the propagation of the plant, and the Japanese are reported to have taken an interest in its development. Up to the present time the collection of "guayule" has been characterized by the improvidence which prevails in Mexico as elsewhere, and the supply may become lessened unless the growth is liberally encouraged and protected.

In 1882 the country had less than 300 miles of railroad (or 2.7 per cent. of the present mileage), confined to the initial enterprise, the Mexican Railroad connecting Vera Cruz with the capital of the republic, a construction which reflects credit upon the persistency of the British capitalists who expended upon it thirty-seven million dollars, or about

* Except where specifically stated to the contrary, prices mentioned in this paper are in Mexican currency, and may be considered as double gold value.

$125,000 per mile, and equal credit upon the engineers who, with the limited experience and equipment available forty years ago, planned and directed this interesting work.

As early as 1837 a concession for a railroad connecting the capital and the Gulf was granted, but abandoned after surveys had indicated its difficulties, and two subsequent concessions were canceled before 1865, when, under Maximilian, the Imperial Mexican Company started work, and in two years built 47 miles out of Vera Cruz and 86 miles out of the City of Mexico. This concession was forfeited by the fall of the Empire, but in 1868 the Mexican Railway undertook the completion of the road, 264 miles in length, and connected Vera Cruz and Mexico City at the close of 1872.

Of the 4000 miles of railroad added in the interval from 1893 to 1908, much consists of branches of and feeders to existing lines, but several important extensions have been completed, a considerable portion of narrow-gage road has been converted into standard gage, and gradients or alinements have been improved.

An important addition is the transcontinental standard-gage railroad, crossing the Isthmus of Tehuantepec by a practically north and south line, less than 200 miles in length. The National Railroad of Tehauntepec connects Coatzacolcos, or Port of Mexico, on the Gulf with Salina Cruz on the Pacific Ocean, each having modern terminals equipped with electric cranes, while the harbor improvements, which cost $100,000,000, permit of quick dispatch for large vessels.

Its strategic value is augmented by the Vera Cruz and Isthmus Railroad, which connects it with the railroad system of Mexico, and by the Pan-American Road being built along the Mexican Pacific coast to Guatemala.

Hawaiian sugar is shipped to the United States in bond over the Tehuantepec Railroad, and preparations are being made for double-tracking the road to meet increasing traffic, as this route is nearly 1000 miles shorter between Atlantic and Pacific ports in the United States than that via the Isthmus of Panama. The road is equipped with oil-burning locomotives; the fuel being conveyed by thirty miles of pipeline from Minatitlan to Port of Mexico, where large refineries are operated.

Another feature is the extension of the Mexican Central lines to Manzanillo on the Pacific coast, giving this road a transcontinental line from Tampico on the Gulf of Mexico, through San Luis Potosi, Aguascalientes, Irapuato, and Guadalajara. Another advance is the con-

struction, now in progress, of a railroad along the Pacific slope which will ultimately connect Guaymas with the above extension. But perhaps the most notable change is the acquisition by the Mexican Government of most of the railroads of the republic by means of a merger, the concentration of the management under a commission named by the President, and the control of traffic charges.

While the Government of Mexico has been generous in granting concessions to railroads, it has exacted rigid compliance with contracts. An evidence of this is a substantial through truss steel bridge spanning

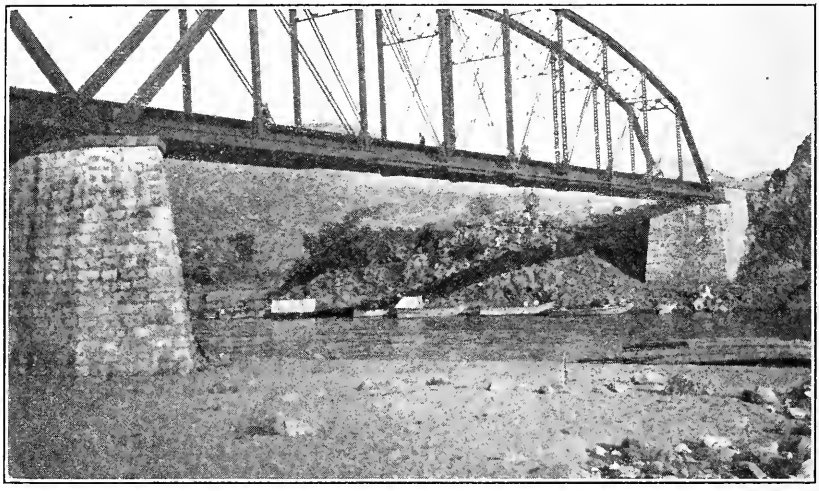

FIG. 3.—One span of a steel truss railway bridge at Balsas, Guerrero, forming the terminus of the Cuernavaca Division of the Mexican Central Railroad. The flat boats shown are utilized to convey freight down the Rio Balsas to various settlements and mining centers.

the Balsas River as the terminal of the Cuernavaca Division of the Mexican Central Railroad, over which no trains pass, as there is no connection beyond, but the concession provided for this bridge, and it remains in place, used only by foot passengers, who tread the ties.

A number of railroad bridges are of large size and some of the highway bridges are of impressive design. At the popular resort of Cuernavaca a modest stream is crossed by a masonry arch bridge 110 feet high, the abutments being enlarged to form circular concourses, or "glorietas" with fountains.

Within short distances one sees the modern and the crude in compari-

son; thus, in passing through a cañon, the Cuernavaca Division of the Mexican Central Railroad uses a curved steel bridge, while a few miles

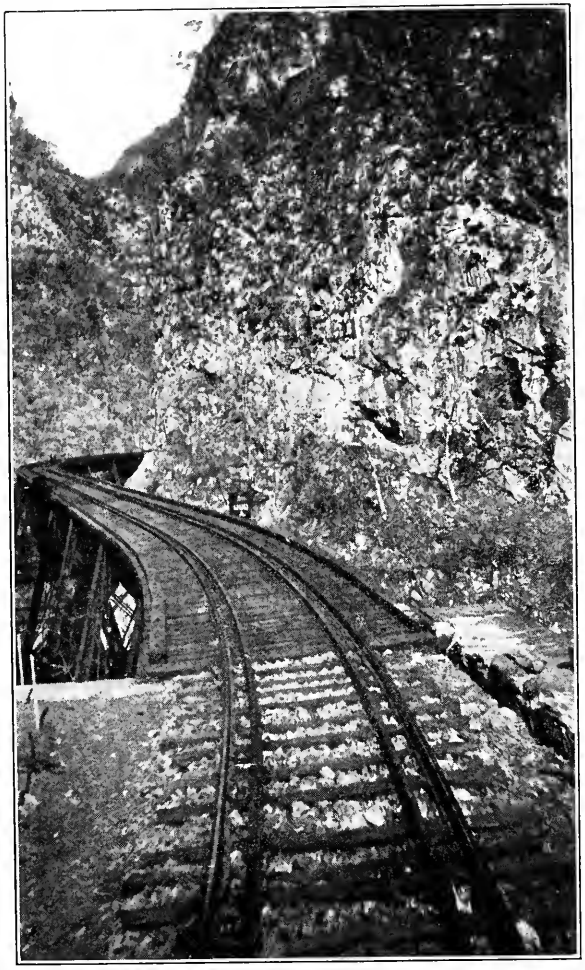

FIG. 4.—Curved steel trestle in a cañon on the Cuernavaca Division of the Mexican Central Railroad.

below is a suspended foot-bridge made from vines and pieces of wood lashed by rope, and close by is a dam constructed of facines (large wicker baskets) loaded with stone, its function being to supply irrigating ditches.

As previously stated, the topographical features of Mexico require that in railroad construction long tangents over waterless deserts alternate with difficult cañon work, bridging arroyas which each year by erosion change their cross-section or form new channels, and climbing mountainous divides.

Little advance has been made in the use of metal ties, to which reference was made in the first paper, the piles of these lying beside the roadbeds unused indicating that their expected superiority has not been demonstrated.

The use of coal has reduced the number of wood-burning locomotives, although on some roads vegetable fuel is still employed, and the liberal application of mineral oil as locomotive fuel suggests the favor in which this is held.

Oil obtained from wells in the State of Vera Cruz has practically displaced other fuel for locomotives on railroad lines reaching the Gulf of Mexico and on the Central Railroad system south of Aguas-Calientes. The large "gushers" which attracted attention by venting uncontrollable volumes, and the efforts to quench the fire which consumed immense quantities of oil, have directed attention to this resource as developed in the State of Vera Cruz, where fuel oils sell at $25 per metric ton at the wells, and are finding a market for internal explosion engines and many other uses.

The application of producer gas to engines is growing in favor, anthracite coal and coke being imported for this purpose, and in the State of San Luis Potasi charcoal is made in meilers and in kilns for such use.

Much of the electrical energy applied in the City of Mexico is obtained from the Mexican Light and Power Company, mainly from an installation recognized as the Necaxa plant, and the report of this company shows that on January 1, 1909, its contracts covered:

Public lighting, 1810 arcs	1,470 H. P.
Private lighting, equivalent to 338,500 16 c. p. lamps.	27,250 H. P.
Power motor units	22,783 H. P.
Electric heaters	1,085 H. P.
Tramways	8,610 H. P.
Total power connected	61,298 H. P.
Add current distributed to El Oro mines and vicinity.	17,775 H. P.
A total of	79,073 H. P.

At the hydro-electric plant (which is supplemented by a steam in-

stallation in the City of Mexico) the maximum power generated during 1908 was 45,000 H.P., or nearly 60 per cent. of the total connected load. The water-power units in place have a combined capacity of 50,000 H.P., which by installations now in progress is expected to be increased to 66,000 H.P., and it is planned to further augment this each year by adding a 16,000 H.P. generator, until three such have been installed.

A large earthen dam, being constructed by sluicing into the embankment clay, sand, and rock loosened by hydraulic giants, is in the course of erection. This dam was planned to have a length of over 1000 feet, a maximum height of 190 feet, a top width of 54 feet, and a maximum base of 965 feet, of which 365 feet is the central clay core. In May two-thirds of the 2,130,000 cubic yards required for the dam were in place, when a slide occurred which moved about one-half of this material, or 720,000 cubic yards, 350 feet into the interior of the dam. This accident will delay the completion of the structure and may limit considerably its storage capacity, and possibly reduce the head on the power station, which was planned to be 1453 feet. Additional reservoirs on other streams are being constructed to store water and divert it to the main dam by means of canals and tunnels.

The mountainous character of central Mexico offers numerous opportunities for the development of water-power, for the descent of most streams is rapid, but the unequal distribution of rainfall into wet and dry seasons requires impounding water on liberal scale when large volumes are to be utilized.

Records of rainfall in the Valley of Mexico, which have been kept for thirty-two years, show an average annual precipitation of 579 millimeters (22.8 inches), the minimum and maximum being 332 and 893 millimeters (13.07 and 35.16 inches) respectively. The major portion of the rainfall occurs in the months of June to September inclusive; the averages for the various months showing:

Month.	Millimeters.	Inches.
January	3.25	0.13
February	6.54	0.26
March	12.2	0.48
April	19.66	0.77
May	45.66	1.8
June	101.12	3.98
July	112.93	4.45
August	117.70	4.63
September	101.32	3.99
October	40.53	1.6
November	10.52	0.41
December	7.43	0.29

The unequal distribution of precipitation appears from the following table:*

RANGE OF ANNUAL RAINFALL IN THE VALLEY OF MEXICO FOR THIRTY-TWO YEARS, 1877 TO 1908 INCLUSIVE.

Month.	Millimeters.	Inches.
January	0 to 20	0 to 0.79
February	0 to 41	0 to 1.61
March	0 to 63	0 to 2.48
April	0 to 65	0 to 2.56
May	6 to 126	0.24 to 4.96
June	26 to 193	1.02 to 7.6
July	48 to 210	1.89 to 8.27
August	40 to 346	1.57 to 13.62
September	43 to 205	1.69 to 8.07
October	3 to 151	0.12 to 5.94
November	0 to 32	0 to 1.26
December	0 to 114	0 to 4.49
Year	332 to 893	13.07 to 35.96

However, some streams have well sustained volumes, and an unusually favorable opportunity for hydro-electric development on the Balsas River in the State of Guerrero was visited. This stream drains an area above the town of Balsas of approximately 17,000 square miles, chiefly in the mountainous sections of Guerrero, Oaxaca, Puebla, Tlaxcala, and Morelos, and its genesis is the perpetual snow on Popocatepetl and Ixtachihuatl, whose peaks have elevations approximating 17,000 feet above sea-level, while most of the water-shed is from 1500 to 10,000 feet above tide.

A measurement at the Mexican Central Railroad bridge at Balsas at low stage showed a discharge of 2668 second feet, or 0.16 second foot per square mile of drainage area, which the topographical and climatic conditions appear to verify; but for most of the year a continuous discharge of 5500 second feet, or 0.32 second foot per square mile, is estimated as available.

*Since the above was written, portions of northeastern Mexico have suffered from phenomenal floods. It is reported that at Monterey 14 inches of rain fell in forty-two hours, and a few days thereafter 20.16 inches fell in ninety-eight hours, or a total of 34.16 inches of rain in one hundred and forty hours.

We may imagine the result in a district where 3½ inches is the average August precipitation, and appreciate the flood conditions by recalling the three days in 1889 when Johnstown was engulfed and central Pennsylvania devastated by a rainfall ranging from 6½ to 9 inches.

A dam 82 feet high, spanning a distance of 300 feet between cañon walls, is planned to back water in a pool over 12 miles long, and a canal 2 miles in length will deliver water from the pool to a power station under a head of 121.5 feet. A second power about three miles below will back water to the upper station by a dam, giving an available head of 29.5 feet.

To meet varying demands, to allow for peak-loads, and to utilize the normal flow of the river as much as possible, installations in the two plants of 60,000 H.P. and 16,000 H.P. respectively are planned.

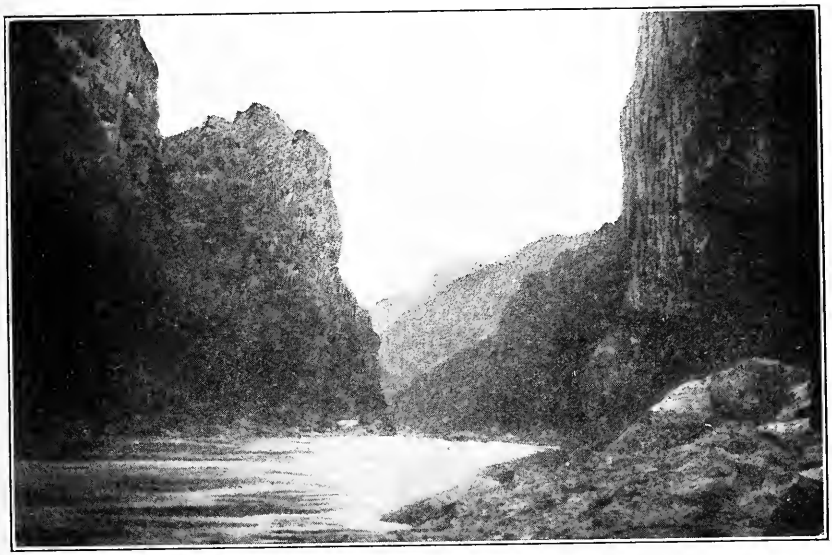

FIG. 5.—Gorge of the Balsas River which it is proposed to span by a dam. The precipitous cliffs shown rise for over 1000 feet above the stream, whose width at the promontory is narrowed to approximately 300 feet at normal water-level.

The hydro-electric plants on the Balsas River are intended to supply power and light to towns, to important mining centers, and to a large sugar-growing territory in the State of Morelos, where there are numerous extensive haciendas. It is also expected to utilize the electricity generated on the Balsas River to displace steam, to improve transportation facilities within haciendas, and to connect these and towns with existing railroads.

Another prospective application is that of elevating water by means

of electric pumps to increase the area of irrigated lands, some installations of this character being in use in the sugar country.

A prominent product of Mexico is sugar, and cane can be grown at an elevation of 8000 feet above sea-level, but it does not tassel above 4500 feet; and, although the soil is excellent, the shallow scratching which much of it receives from the sharpened logs used as plows, and

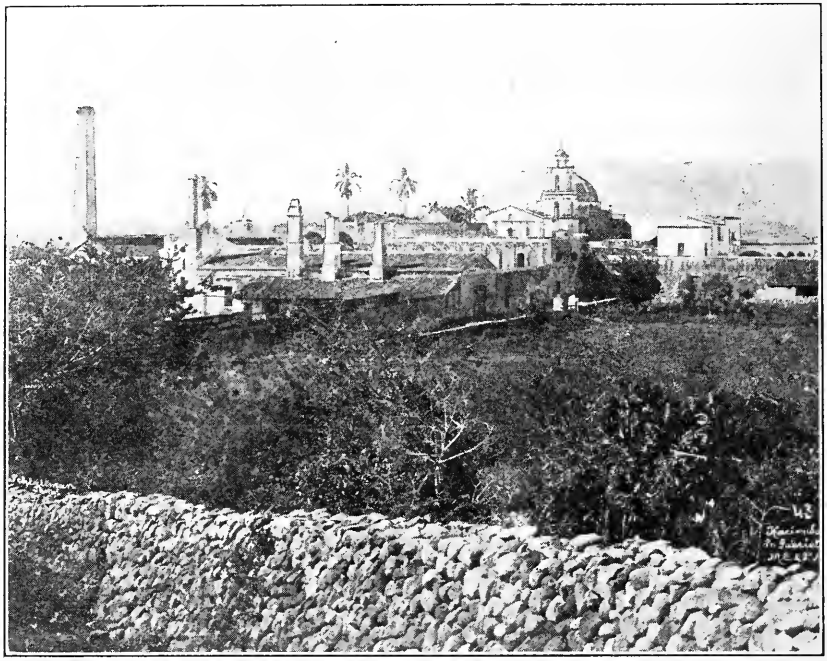

FIG. 6.—Group of buildings on a large sugar hacienda in the State of Morelos, Mexico.

the limited fertilization applied, reduce the yield below that of Hawaii. On one side of a mountain range convenient to railways may be seen a large "hacienda," equipped with modern machinery of approved type, while on the opposite side crude rolls, driven by water or animal power, crush the cane.

Some of these modern haciendas employ steam-plows for cultivating the ground; have equipments of steam-derricks, cane and bagasse carriers, rolls, vacuum pans, centrifugals, filter presses, and other acces-

sories, economical boilers, high-duty steam-engines, and handle their cane and products on narrow-gage railroads by steam locomotives.

Other mills are ancient, and in some are old Spanish rolls of copper; open-air evaporation is used; and, in crystallizing, the sugar in earthen molds is blanketed with clay to extract the molasses. Many haciendas produce no marketable sugar, but convert the cane into alcohol (aguardiente).

Pretentious textile works are also in evidence within a short distance of wooden looms, wool wheels, and hand cards operated in cane or adobe

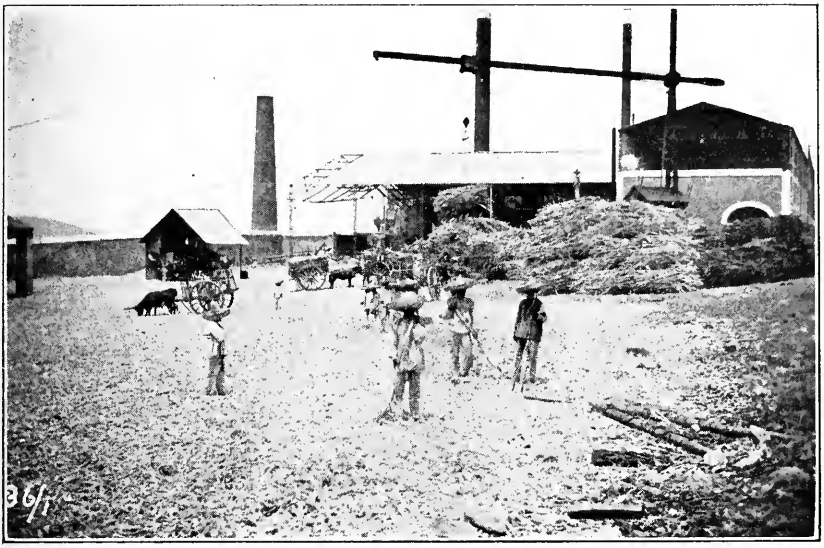

FIG. 7.—Interior of a sugar hacienda in the State of Morelos, Mexico, showing sugar-cane being handled from ox-carts by steam derricks, and in the foreground bagasse drying for use as fuel.

shacks occupied by the natives, who thus produce excellent "sarapes," "rebosas," or other woven goods of wool clipped from the numerous herds of sheep and goats, or of cotton harvested from large areas under cultivation.

The first Mexican journey was through sections then remote from railroads, and the one made a few months ago was distant from both railway and wagon roads, where the crude methods noticed in northern Mexico twenty-seven years ago were found in use in the mountains of Oaxaca. Among these is the ancient Catalan forge, in which iron ore is

fed to an open charcoal fire intensified by blast supplied by trompe, in which falling water entrains air. The bloom made in the fire is wrought under a helve hammer operated by a water-wheel, and rewrought into bars or anchovies, which are marketed locally for from three to five cents gold per pound.

Some of the charcoal blast furnaces mentioned in "Notes on Engineering in Mexico" are also active, and the delicate castings from furnaces or iron puddled with pine wood are produced in the manner therein described. In several prominent cities scrap furnaces are operated with fuel supplied by gas producers and connected with rolling mills producing merchant iron, and foundries and machine shops furnish much of the repair and some of the new work required. As a rule, these industries are inclosed to prevent pilfering, and workmen are searched upon leaving the plant.

At Monterey, in the State of Nueva Leon, a modern iron and steel industry was established in 1901 by the Cia. Fundidoro de Fierro y Acero de Monterey, S. A. The plant consists of one blast furnace, 80 by 18 feet, one Bessemer converter, three 35-ton open hearth furnaces, one composite mill to roll beams and shapes or rails, a merchant mill, spike works, foundry and machine shop, and other accessories.

The blast furnace is fed with iron ores obtained in northern Mexico, the mixture ranging from 57 to 62 per cent. of iron, and closely averaging 60 per cent. iron. The coke used is one-half domestic, one-half foreign, and limestone is brought from nearby quarries. The domestic coke is produced from coal mined in the State of Coahuila, 200 miles from Monterey, and for smelting purposes, owing to the percentages of ash and sulphur, is mixed with cokes shipped from the United States and Europe to Tampico, and from thence 322 miles by railroad to Monterey.

Pig-iron is cast in sand when not supplied as direct metal in ladle cars to the Bessemer converter (formerly a feature of the Pottstown, Pennsylvania, basic Bessemer plant), where it is partially blown, and is then carried by ladle to open hearth furnaces already charged with scrap; this duplex process accelerating the rate of conversion and augmenting the open hearth output; the cast ingots passing through soaking pits to the blooming and roughing mills, heating furnaces, and then to the composite trains. When visited, the mill, which has a capacity double that of the blast furnace and converting equipment, was running on an order for 20,000 tons of 85-pound open-hearth steel rails for the Mexican National Railroads.

The general management is by Mexicans and most of the employees are natives, but department heads and many skilled workmen are foreigners. The labor basis at the plant is $1.50 Mexican per day, equivalent to 75 cents gold, but the number of employees exceeds that usually found in similar works in the United States. In 1907 nearly 18,000 tons of steel ingots were produced and 30,000 tons of manufactured steel, mostly open hearth, were turned out.

Practically all the domestic coal produced in Mexico is mined in the State of Coahuila, near the United States boundary, where about 1,500,000 tons are obtained annually. In 1907 the output of the Coahuila coal fields was 1,265,719 metric tons, about one-third of which was converted into coke. Exploitations have followed the mineral for 4500 feet on a slope, and a shaft 930 feet deep is in use.

The towns, railroads, and other improvements, for which these coal deposits are responsible, have transformed a desert country into an industrial center, most impressive to one who first knew the coal as a mere prospect.

The coal costs about $2.00 gold per ton to mine, and, owing to the percentage of ash, washing is necessary to prepare it for coking, 20 to 25 per cent. passing away in the tailings; hence, two tons of coal as mined are necessary to produce a ton of coke, and this product commands about $6.50 gold per ton at the ovens.

But the fuel requirements of Mexico are more than double the output of the Coahuila fields, and domestic coal and coke compete with foreign fuel at the capital and other centers of consumption on the main plateau. The railroad freight rate from the Coahuila mines to the City of Mexico, 835 miles, is $4.00 gold; the same amount is charged on foreign fuel carried 264 miles from Vera Cruz, but in the latter case the fuel is elevated from sea-level to the capital, 7500 feet. Fuel is, therefore, an important problem, and one purpose of the recent journey was to inspect prospecting work and reconnaissances in Oaxaca, which for one and a half years have been carried on under the direction of my son and associate, J. L. W. Birkinbine.

This is neither the time nor the place to discuss the details of the exposures made by the use of diamond drills and many exploratory workings in searching for coal and iron ore in the State of Oaxaca. But it may be of interest to state that three bituminous coal basins of considerable extent and large deposits of rich iron ore have been located, and that from one of the fields a dense coal, burning without smoke, is obtained, intimating a close approximation to anthracite. In this coal

the volatile matter is low, but, as in all Mexican coals, the ash is high.

The Coahuila coals are classed as cretaceous, while the Oaxaca coals are believed to be in the Upper Jurassic formation.

As the Oaxaca coals are found at altitudes ranging from 6000 to 7000 feet above sea-level and within 300 miles of the capital, they offer opportunities for cheap transport as compared with the Coahuila coals mined at an elevation of 1500 feet and carried over 800 miles to the City of Mexico.

Reconnaissances demonstrate that, notwithstanding the mountain-

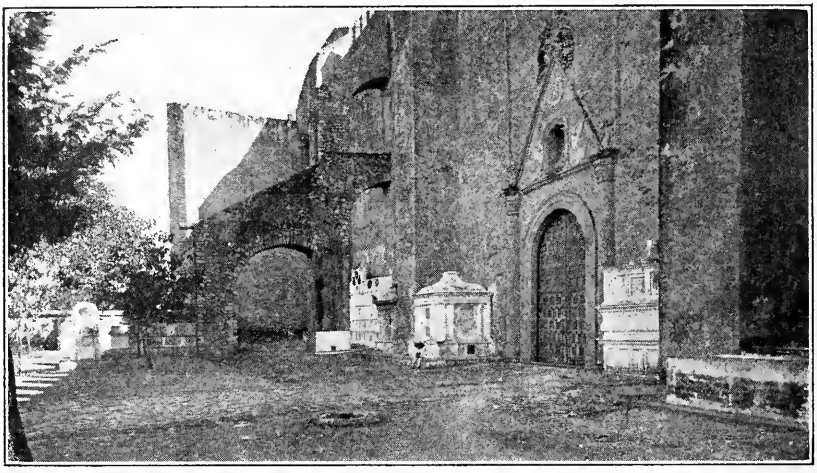

FIG. 8.—Flying buttresses of the ancient cathedral in Cuernavaca, reported as having been constructed in the sixteenth century.

ous character of the country, satisfactory railroad routes are obtainable which, besides bringing the Oaxaca coal into market connection, can be extended to the Pacific coast.

While the mines of Mexico have been the cause of many extravagant statements, the country is rich in mineral, and most of the States are producers of importance. In the paper which this article supplements one of Mexico's great iron ore deposits was described, and a résumé of important mines or quarries would fill many pages of the "Proceedings."

In the mountainous sections of Oaxaca and Guerrero covered in the last visit the mines produce gold, silver, copper, lead, antimony, and

other minerals; one lead smelter visited being equipped with American impulse water-wheels working under a head of water of 60 feet and operating American rotary blowers. This smelter was supplied with water-jacket and metal tuyeres, and all of this installation had been transported on the backs of animals for 75 miles.

Peopled by a succession of generations, which for centuries have depended upon wood or charcoal made therefrom as fuel, little valuable timber remains, although the Oaxaca mountains sustain a fair growth of gnarled and stunted trees; the herds of sheep and goats preventing the development of any decided new growth.

This paper is merely a sketch outline of general features which could be filled in with engineering details, including extensive harbor improvements, governmental or municipal buildings, revised alinement and gradients of railroads with their bridges and tunnels, design and equipment of manufacturing industries, extent and product of mines, mills, and haciendas, description of water-power installations and distribution of electrical current, public water-supplies, drainage systems, etc. But from what is presented it is evident that Mexico will have wonderful progress to exhibit in celebrating next year its centennial of independence, or rather commemorating the spark struck by Hidalgo in September, 1810, from which resulted the flame of patriotism which was not extinguished during fifty years of internal strife between warring factions led by ambitious leaders, but was fanned into renewed fervor by the unsuccessful effort, backed by European influence, to establish an empire under Maximilian in 1866.

At the Centennial Exposition in Philadelphia in 1876, General Porfirio Diaz represented the republic of Mexico. Since that time he has, with the exception of four years (1880 to 1884), been the President and practically the dictator of our neighbor republic, guiding it toward a future which should place Mexico as a permanent feature of "governments of the people, by the people, for the people," which we trust will characterize the entire western hemisphere.

In two interviews with President Diaz I was impressed with the intimate detailed knowledge he possesses of his country's needs and possibilities, and his apparent enthusiasm over any project which promises national advancement. He not only analyzes figures, but understands drawings, an accomplishment unusual among men in public life.

When Cortez landed in Mexico and initiated the Spanish conquest, the knowledge that Columbus had found the land we know as North

America was less than thirty years old. But the conqueror found numerous impressive temples and constructions which evidenced a civilization covering centuries, and now Mexico is uncovering ruins which offer fertile fields for archæologists.

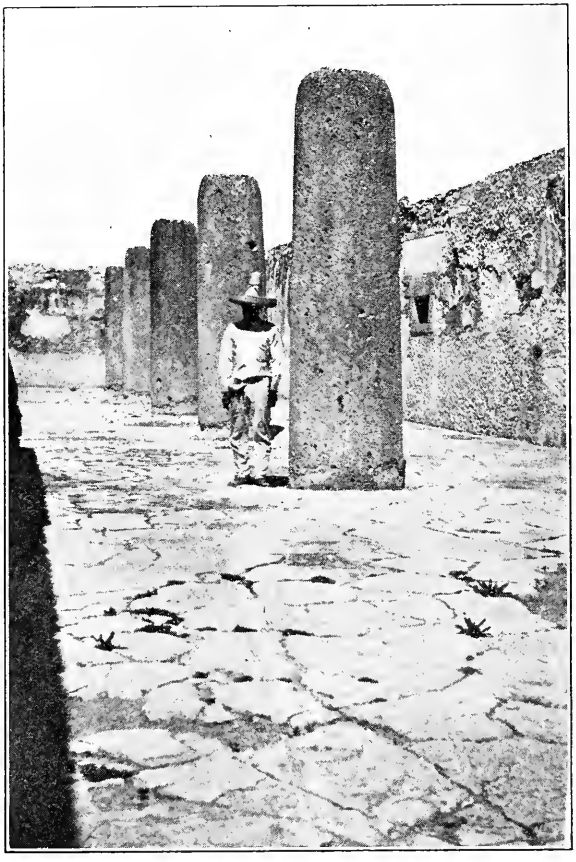

FIG. 9.—A portion of the ruins of Mitla, Oaxaca, which have been excavated, showing the Hall of Monoliths.

The Mitla ruins, near Oaxaca, present interesting examples of mosaic work on heroic scale, done by people of whom no authentic history has been discovered, and in other localities explorations are being conducted under governmental authority.

During the journey through Oaxaca, I lived among people who trace

their history back to the sixth century, and traversed territory evidencing that in the past it had sustained a population greatly in excess of that now occupying the towns, pueblos, and ranches.

Details concerning the country traversed and the crude methods

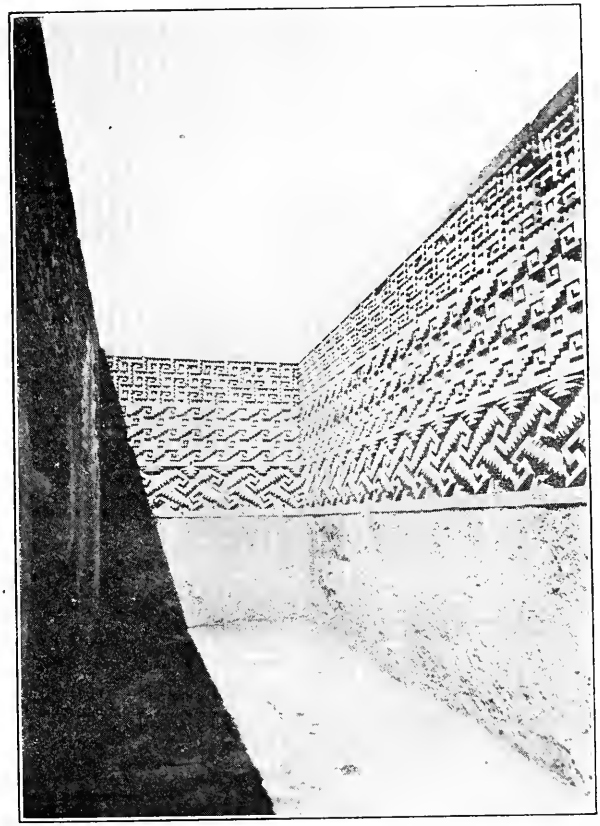

FIG. 10.—Part of the ruins of Mitla, Oaxaca, showing a portion of the East Corridor of Mosaics. Note the intricate pattern, the small pieces of stone being so well laid as to have withstood the ravages of centuries.

followed by the interesting people in Oaxaca are given in the paper "A Trail through the Mountains of Oaxaca, Mexico," by H. E. Birkinbine, who was my companion and assistant in the investigations.

The methods of agriculture and industry, and the means of travel, mainly rugged mountain trails, carry one far back in history; and the

knowledge that the same methods were in use in Oaxaca when our own progressive country was a wilderness awakens interest. But when evidences of advancement are noted where modern appliances have been introduced, and the possibilities of good soil and the equitable climate due to the altitude are recognized, the future of southern Mexico looms bright, and the same progress shown in other sections of the republic may be anticipated.

A TRAIL THROUGH THE MOUNTAINS OF OAXACA, MEXICO.

HENRY E. BIRKINBINE.
(Junior Member.)

Read June 15, 1909.

THIS paper is not technical, but, as the title indicates, treats of a portion of the republic of Mexico concerning which little information has been published, although this region was peopled long before the section of North America in which we live was known. An effort will be made to describe the physical features, the people, and their industries and habits, as noted while on a trail through the mountains in the northwestern part of the State of Oaxaca.

The State of Oaxaca, whose capital bears the same name as does the State, lies southeast of the City of Mexico, and, with Chiapas, forms the southernmost portion of the republic of Mexico. Its coast line, lying entirely along the Pacific Ocean, has a length of 300 miles, and the railroads within the State do not cover more than 370 miles. The topography, which for the most part consists of series of mountain ranges with intervening valleys, varies from sea-level on the Pacific coast to 10,800 feet, the average elevation probably exceeding 5000 feet above tide.

This State has an area of 35,392 square miles, about four-fifths of that of Pennsylvania, and is settled by a million people, of whom approximately one-third are meztizos and whites, and the remainder composed of fourteen Indian tribes, the Zapotecas and Mixtecas being by far the most prominent. The route traversed on the trip was mainly through the country and towns settled many centuries ago by the Mixtecas, who speak a language of their own. A few Mixteca words are given to indicate the character of the tongue and the difference between it and the Mexican, or Spanish, language.

As instances: "ñu" is the Mixteca word for the Spanish "lumbre," meaning "fire"; "tree," which in Spanish is "arbol," the Mixtecas call "ñutu"; while "hombre," the Spanish for "man," they designate as "te." Also "corn-fodder," which is known by Mexicans as "zacate," is termed "dndojo"; "cuñu" replaces the Spanish "carne" for "meat";

"mountain," "cerro" in Spanish, is called "yucu"; and the familiar word "pan," meaning "bread," becomes "yxtatila."

The Mixteca peons, a peaceful, music-loving race, wanting in hygiene and method in their life and labors, have unusual powers of strength and endurance. The men carry heavy burdens and travel all day at a smooth running-walk, over hills, along valleys, and through streams, for from 25 to 37½ cents gold a day. As an instance, it was related that a "mozo," man-servant, carried a barrel of sugar over the mountains to the camp, a distance of eighteen miles, and also that a native bore a

FIG. 1.—Typical topographic features in the vicinity of Huajuapam, Oaxaca.

barrel of cement along a sidewalk in the City of Mexico. With the aid of a piece of rope, and using the "sarape," native blanket, as a cushion, the Indian carries burdens which in this country require the services of two or three men. A case experienced was that of a "mozo" bearing upon his back a metal steamer-trunk, filled with clothing, as well as a large dunnage-bag full of "sarapes" and blankets, from the railway station to the second floor of the hotel, a mile away. An example of their endurance, even when young, is that of a barefoot Indian girl, ten years of age, walking thirty-five miles over the rough mountain trails in a day and a half to earn one dollar gold a month.

Despite the strenuous exertion on a day's trail of from thirty to forty miles over the rugged mountains, and the heavy burdens borne, the Indians seem to take little rest. At night the "mozos" sit around the camp-fire and chatter long after every one else has "turned in," and in the early morning, when the camp awakes, they have been astir for some time and have prepared the pack train for the day's work. Along the trail their meals consist of "tortillas," thin cakes made of corn-meal ground between stones, which they buy at the villages passed through, while in the towns they can purchase for two cents gold a meal of soup, meat, "frijoles" or beans, and "tortillas."

On the trail one meets man, woman, or burro, each carrying a load of approximately the same weight, but the woman often has the additional burden of a child slung over her back in a "rebosa," a thin native shawl with a fringed edge.

The tenacity with which the people cling to the primitive methods is illustrated by the fact that when iron wheel-barrows were first brought to the workings, the miners would wheel them out of the opening with a load of coal or waste, and then, turning the implement upside down and bearing it on their heads, would trot back into the drift. Another case brought to attention was that of a peon, who, accustomed to the use of the Mexican plow, consisting of a sharpened log with a stick attached for a handle, cut off one handle of a new American plow.

In towns, or occasionally on the trail, the costumes differed according to the wealth and position of the wearer; those of the men varied from up-to-date European suits to the white, or once white, cotton garments, much resembling pajamas; the conical hats ranged from felt with elaborate gold or silver embroidery to straw; and where shoes could not be afforded, they either went barefoot or wore sandals. The clothing of the women was of the latest European fashions or the native low-necked bodice and skirts, much frayed about the edges, and their head-coverings were lace "mantillas," or scarfs, or the domestic "rebosas," those who could not obtain shoes usually being barefoot.

Occasionally a man is seen in the "charro" costume of short jacket, bright colored belt, and tight-fitting trousers which button or hook along the outside of each leg, these garments being sometimes decorated with gold or silver buttons or heavily embroidered with braid of the same metals.

The high peaked hats with broad turned-up brims, which are worn by both men and women while on the trail, serve the double purpose of a protection from the sun and a convenient method of carrying in the

brim, so as to be readily accessible, small change, trinkets, cigarettes, and fruit, or at times another hat is perched on the peak.

The "sarape," from which the "mozo" is never separated, is used as a blanket at night, to wrap about the upper portion of the body and to cover the mouth in the cool of the evening and early morning; lies on the ground nearby when the owner is working; is carried over the forearm or shoulder while trailing; and is used as a cushion when heavy bundles are carried.

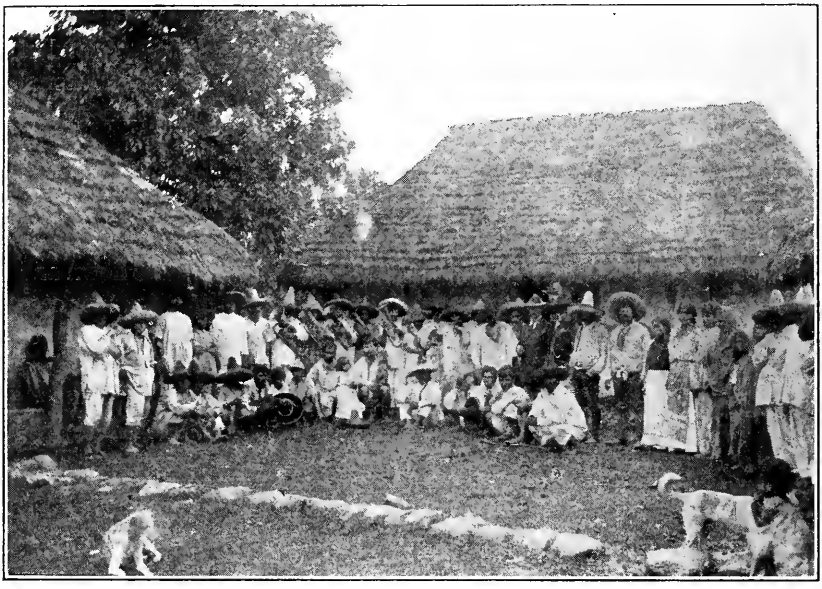

FIG. 2.—Group of Mixteca Indians with local band, showing the character of the habitations.

On the trail other travelers are met, usually "peons" driving pack trains of burros carrying large boxes, bags, jars, or bundles, and often accompanied by the young animals, which solemnly trot along beside their mothers, stopping to gaze at the stranger with wide-open eyes. Sometimes one meets a man riding a fine horse, preceded by a "mozo" carrying a gun and followed by another bearing a wicked looking "machete." From each traveler is received a "buenos dies," or "buenos noches," the Spanish for "good day" and "good evening," and also a raising of the hat from the "peons," men and women, who will

pass on without making a mistake in the manufacture of another hat, which they weave from strips of palmetto leaves while walking or riding over the trails.

The narrow, winding, steep trails lead up and down the sides of the mountains, from whose summits are obtained impressive views of the valleys lying a thousand feet or more below. In the valleys, however, the trail broadens out into a road, "camino real," which leads across the valley with its arroya and through the towns, and on which are seen occasional "carretas," two-wheeled carts of wood doweled together with wooden pins and tied with ropes, drawn by a pair of plodding yoked oxen.

During the wet season the water from the heavy rains, in its course to the river-bed, cuts deep "barrancas," or arroyas, with nearly vertical sides, in the soil, and to cross these gulleys the trail winds around until it reaches the end of the "barranca," or a place where the slope of the bank permits a descent to the bottom, and further along a climb up the opposite bank.

Along both sides of the road, bordering the fields or defining the village streets, rows of aloes, or maguey plants, from which is obtained the native drink of "pulque," grow to large sizes, and when blooming send up from the center of the plant a long shoot, about fifteen to twenty feet in height, from whose top are put out symmetrical branches bearing clusters of flowers and giving the effect of a lofty branched candlestick. The prickly pear, which in our climate is nursed in flower-pots, grows to trees from fifteen to twenty feet high in Oaxaca.

In the valleys, on both sides of the roads, lie the fields in which are raised wheat and maize, and in some protected sections sugar-cane flourishes, while anise-seed is occasionally seen growing. The perpetual summer of the region permits of one field being plowed while those adjoining show the green blades springing from the ground or a crop ripe for harvest. Modern agricultural implements were not used by these people, the tilling of the ground being usually accomplished by means of a plow, said to resemble that used by the ancient Egyptians, where a sharpened log, sometimes shod with iron, fitted with a stick for a handle, scratches a shallow furrow in the soil. These plows are drawn by a pair of yoked oxen urged by a thorn fastened in the end of a long stick. The field may also constitute a threshing floor, where, after the grain has been trodden out of the hulls by two or three horses and a burro hitched together and driven in a circle with the driver as the

pivot, the first favorable breeze is utilized to waft away the chaff, the grain falling to the ground when the mixture is tossed into the air. After a corn-field has been harvested, the stalks, or "zacate," are stored in the branches of trees to prevent them becoming the food of animals allowed to roam, while the corn is conveyed to conical adobe bins.

The habitations beside the trail are usually of cane with thatched roofs, and some of these have along the ridge-pole a line of earthenware

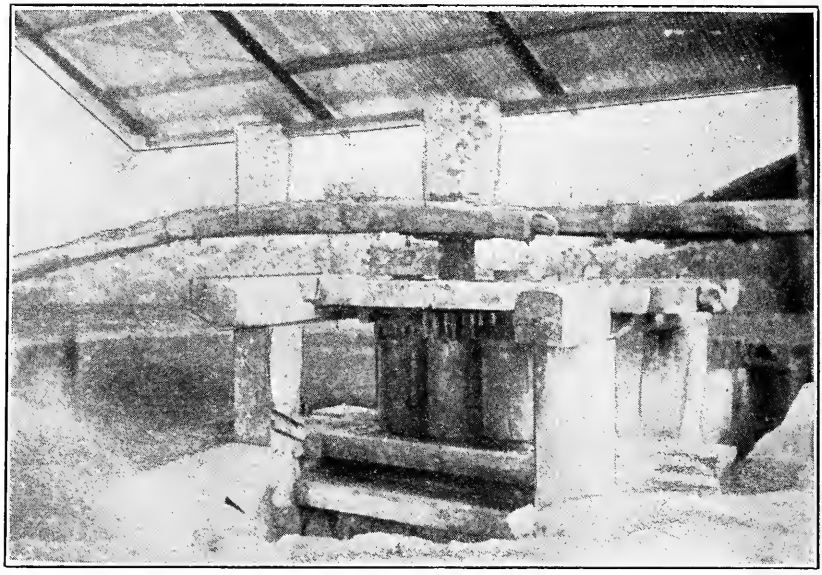

Fig. 3.—Sugar rolls made of copper and operated by animal power. They are claimed to have been introduced by the Spaniards at the time of the Conquest.

jars, broken vertically down the centers, overlapping so as to prevent the leakage of rain-water. Nearby some of these shacks are hemispherical bake-ovens, with a small hole in each, built of stones set in lime mortar, for the Indians burn their own lime.

From some of the huts passed issued the noise of the wooden looms weaving the "sarapes" with wool cut from the ranging herds of sheep and goats, carded, spun, and dyed by hand; while from others came the whirr of the modern sewing-machines, and the agencies of these implements can be seen in all the large towns.

The outskirts of the villages are composed of scattered huts built of cane and sometimes inclosed by organ cacti planted in rows so as to form fences; while in the towns the houses, as a rule, are constructed of sun-dried adobe bricks manufactured nearby, and some are also plastered with lime mortar, often painted, the predominant colors being pink or pale blue. The roofs, instead of being thatched, as in the outskirts, are constructed of tile made in the vicinity, or of large, square, flat bricks resting on "vigas," or wooden beams, laid across the tops of the walls with merely sufficient slope to carry off the rain-water. The principal streets are paved with cobble-stones, as is also the "plaza," or public square, near the main church, where the people have their market.

The church is always the most prominent feature of the town, its bare walls and white towers rising above all other buildings, and, at the points on the trail from which the town can first be seen, are placed crosses, which passers-by decorate with vines, branches, and flowers. Wayside shrines and crosses also give evidence of the religious sentiment of the people.

Parian, elevation 4900 feet, the puebla, or small town, from which the start of the journey was made, is a collection of adobe or cane huts, whose roofs are thatched with split aloe leaves or grasses. It is built about the station where the narrow-gage, wood-burning locomotive of the Mexican Southern Railroad connecting Puebla and Oaxaca pauses for wood and water after climbing through rocky gorges, beside tumbling streams, and passing through the "tierra caliente," or hot country, where may be seen the graceful palms and green fields of sugar-cane.

Mountain horses and a pack train of mules and horses were in waiting to carry the party with their tents, provisions, and luggage over the steep, narrow, and often rocky trails across the mountains, whose crests attain elevations above the sea of 8000 to 9000 feet, and which, with their foot-hills, separate the various towns from one another. To relieve those wearied by horseback-riding, a chair built so as to be supported by poles resting on the shoulders of carriers had been provided, with "mozos" in sufficient numbers to act as relays.

The horses and mules, having lived among the mountains, were sure-footed and safely traveled over steep, rocky slopes, along narrow side-hill paths, or through stony stream-beds; the only misfortune occurring when a pack-horse, in trying to free himself of his load by bucking, lost his footing on the trail along the mountain-side and rolled into the

river below, wetting the contents of the suitcase lashed to his back and causing the camp that night to resemble a "dressed" man-of-war. For the good of the riders as well as of the horses, it was considered advisable to dismount when descending especially steep or rocky trails, the animals being led by means of long lariats about their necks.

At Nochixtlan, elevation 7200 feet, a town of 4500 people, 27 miles from Parian, a stop was made at the hotel, a one-story affair whose brick-paved rooms with high ceilings opened onto a court paved with cobble-stones. About 6 o'clock that evening the bells in the nearby church began ringing, two bands started playing, and occasionally a cannon was discharged, a preliminary celebration of the following day's anniversary of the granting of the new constitution to Mexico in 1857. These noises were intermittent, ceasing for a while and then breaking out anew. One band did not wait for the other to complete its selection before starting to play, but each gave its own piece in its own time and key while walking from place to place on the public "plaza," and the bells were also independent of the bands. At night the inhabitants lighted rockets and threw them into the air to choose their own courses, and next morning, when the journey was continued, the celebration had not abated.

Outside of the town are a number of hills whose crests are littered with shards of broken ancient pottery, some carved and others painted and enameled with bright colored figures and fancy designs. On the summits of these hills, from what are claimed to be graves, are obtained small idols carved out of stone and drilled through the back to accommodate the thongs by which the idols were carried. Some of these images consist of the head only, but others show the figure in a position of squatting on the heels with the knees protruding in front, the hands being clasped or the arms folded over the breast, and some have a crown upon the head while the features vary from decidedly Egyptian to Asiatic.

At Santa Maria Tiltepec, a little town at the foot of one of the mountain ranges, consisting of probably forty cane or adobe thatched roof huts and situated about forty miles from the railroad, stands a large stone church whose elaborately carved façade contains winged images in niches, and whose interior includes ornate decorations and gilding, as well as an organ, showing the hold of the church upon the scantily clad inhabitants of the vicinity. In the wall around the church as well as in the side walls of the structure are inserted stones with intricate carvings, which were claimed to have been parts of an older edifice,

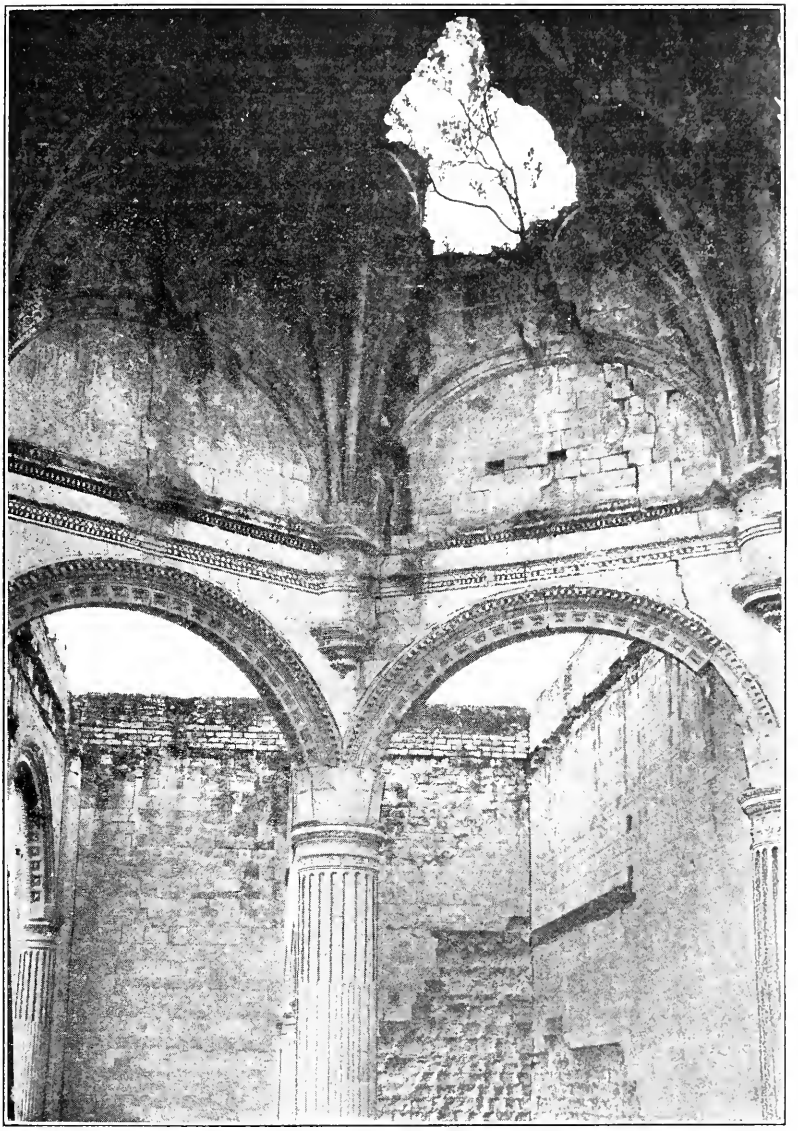

FIG. 4.—Interior view of damaged dome of sacristy at Teposcolula, Oaxaca. The ornamental character of the stonework is well illustrated.

while well up on the side of the building is set a tablet bearing the date 1689.

Teposcolula, elevation 7500 feet, a town with a population of about 5000, located 28 miles from Nochixtlan, the next stopping-place, gave evidence of having once been of material importance, being reported to have at one time been the capital of the State. Here stands a church, bearing the date 1763, with an attached cloister, and also the ruins of an older church. Fluted sandstone columns, from thirty to forty-two

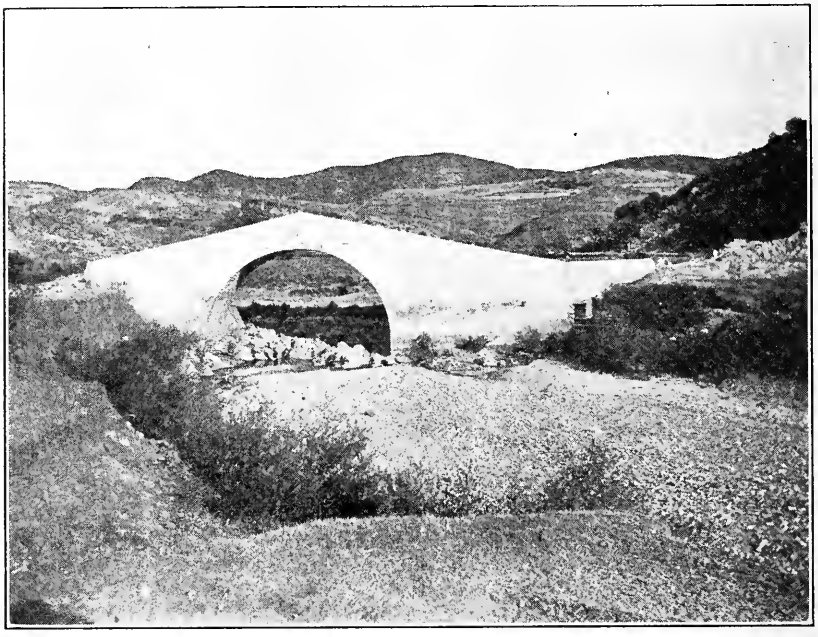

FIG. 5.—Masonry arched trail bridge near Teposcolula, Oaxaca.

inches in diameter and twenty-five to thirty feet high, support handsomely carved arches with spans of about thirty feet and a dome, from which part has fallen, a good-sized tree growing from the rim of the hole. The columns are built up in sections, each formed of a number of segments made of such size as to be transported from the distant quarries on mule-back.

On one side of the town, crossing a stream, is a bridge of masonry plastered with lime mortar, giving the appearance of concrete; and in another locality is a bridge formed by building stone piers and resting

upon these huge logs thrown across the stream between two pairs of tall sabino trees.

Near a pueblo, called San Pedro de Salinas, are salt fields where the saline water oozing through the earth is evaporated, leaving a deposit of salt on the top soil, which is scraped into piles by the inhabitants and placed in holes in the ground filled with water, dissolving the salt. After the earth has settled, the brine is decanted into a vessel and carried to the huts, where evaporation by boiling leaves the domestic condiment.

Tlaxiaco, a town with an elevation of 7000 feet, having 8000 inhabitants, with 4000 people in the surrounding pueblas, was reached after a ride of thirty-five miles from Teposcolula, being ninety miles from the railroad or nearest continuous wagon road. Claiming it to date from the sixth century, the residents are proud of their town, which is the political head of the district and boasts of two four-wheeled passenger vehicles, which, however, must remain within the valley, where the trails are sufficiently wide to permit of their use.

This progressive town has separate schools for boys and girls, and its streets are illuminated by electric lights, the current being supplied from the municipal power-plant containing dynamo, engine, and a 30 H. P. boiler using wood as fuel. The machinery was brought over the mountains with great difficulty, trees and "dead men" being employed to assist the oxen in hauling the sections, which were placed on rollers.

Tlaxiaco supports an orchestra as well as a good band, the natural talent for music being illustrated by the fact that many of the performers are boys. The music-loving character of the people was demonstrated by finding that the disturbance of one's rest at 3 o'clock one bright moonlight morning by the soft music of the orchestra's guitars, mandolins, violins, flutes, and clarinets was because the night was so beautiful the members of the orchestra felt they should serenade through the town.

Another novel experience was that of sitting on the balcony when the band was giving a serenade and looking down upon the dark-skinned musicians in peaked hats, white clothes, and a "sarape" about the shoulders, standing in an open circle and playing familiar music with modern instruments by the aid of the light of a candle resting on each music-stand. This band has the advantage of having interested in it one of the prominent citizens, who sends away for the music, varying the selections from waltzes to marches, and even including operatics and classics.

It was stated that at the Fourth of July celebration of the American

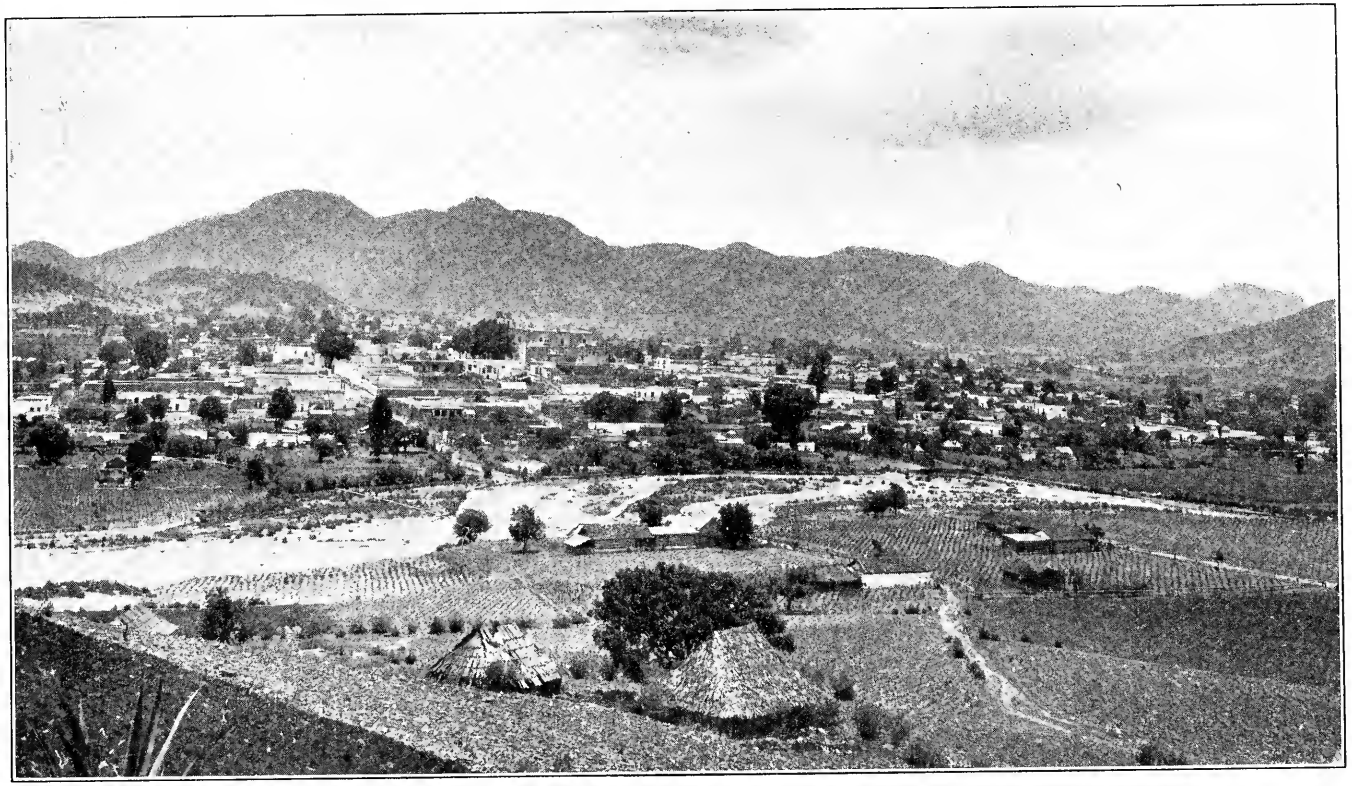

FIG. 6.—Panoramic view of the city of Tlaxiaco, Oaxaca, and surroundings.

engineers employed by the Oaxaca Iron and Coal Company, into which the officials and residents joined most heartily, the band from a town thirty miles away came into Tlaxiaco playing one of Sousa's stirring marches.

Three years ago, when the engineers of the above company first settled in Tlaxiaco, an American was a curio, but now there are in the town English signs, including those of "shu shine" and "barber shop."

A caller upon one of the prominent citizens found in his parlor long mirrors, carpet, parlor furniture, and a piano, all of which must have been carried over the mountains by "mozos" or mules. There were also in the town several billiard tables, which had been brought from the railroad in a similar manner.

One of the town "plazas," where the market is held on Saturdays, is a square paved with cobble-stones and having in the center a fountain from which some of the residents obtain their supply of water and carry it to their homes in jars. This, with two other similar fountains, constitutes the town water-supply system. On market days the "plaza" is crowded with 4000 to 5000 people, who spread their wares upon mats laid over the stones and will sell their stock, or trade the fruits and cane of the hot country for the pottery, "sarapes," etc., of the towns.

On Saturday night, after the market is over, the pigs of the town clean up the "plaza" refuse, and a Sunday morning's form of excitement is the arrest of the pigs, if the officers succeed in their efforts to catch the animals.

A sport of the Indians is "pelote," or hand-ball, played with a ball made of cloth. Some knock this against the side of a house, having courts marked out in the dirt, similar to racquet; while others have a game resembling tennis, using a line as an imaginary net, with courts marked out in the dirt on both sides of this line. When two Americans played "pitch and catch" on the "plaza" with baseball and gloves, the natives left the shops and formed an aisle up and down which the ball traveled, with a fringe of people two and three deep; and a wild pitch, which struck a stone and, glancing off, hit a native boy on the thigh, caused only laughter and joking in a tongue which could not be understood.

The friendly spirit of the people was also shown by viands sent to our table, such as turkey, boned, minced, and stuffed back into the skin, a roast young pig, and various kinds of "dulce," or desserts.

Leaving Tlaxiaco to visit some of the coal deposits, which were being exploited by the company previously mentioned, the trail was similar

to that leading from the railroad, and after crossing the rugged summits of a number of hills, their steep sides were descended to the Tlaxiaco River near its gorge, where several workings were located. Other openings were visited near Mixtepec, a collection of huts and stores

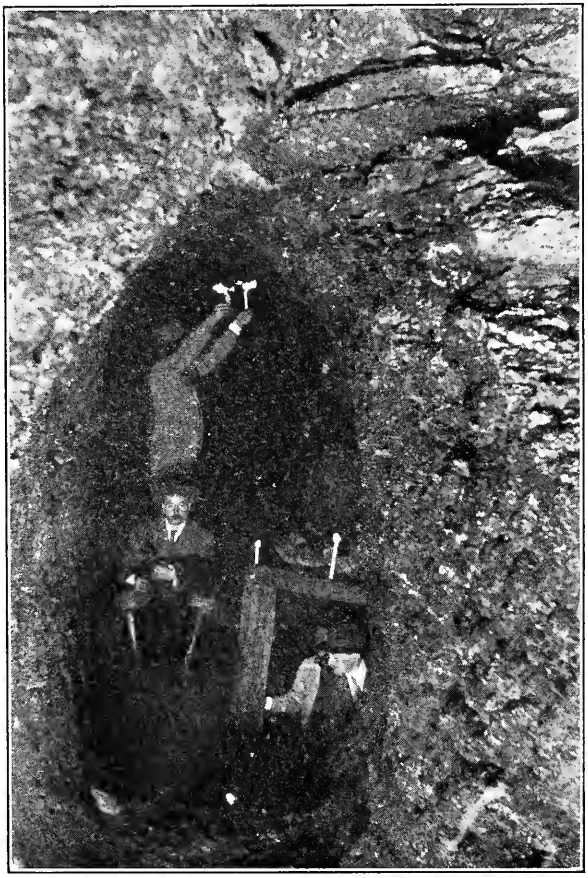

FIG. 7.—Flashlight taken in the coal drift, from which a semi-anthracite coal is obtained.

about a church, where coal seams were being investigated, the miners using a carrier similar to a stretcher to remove the coal and waste from the drifts. In locating the properties the company was compelled to have a geodetic survey made, selecting a base-line, and tying it to governmental triangulation stations where possible.

Many of the trees in this vicinity have hanging from their branches a fungus, much like our southern moss, which hides the leaves; and from the branches of other trees grow varieties of orchids, the plant resembling the clustered spines of a pineapple top and suspending a chain of bright-colored flowers.

FIG. 8.—Gorge through which the Mixtepec River makes rapid descent. The proportions are indicated by comparison with the individuals on the cliffs and rocks.

Near Mixtepec the camp for the night was made by the Mixtepec River, where this stream leaves its fringe of "sabino" trees in the rolling country and enters a gorge whose nearly vertical walls are about 170 feet high and 230 feet apart.

Mina Consuelo, a little settlement in a narrow valley between high hills, from whose crests the coyotes howl at night, is where most of the exploitation has been done, and a welcome sight upon coming over the summit of a hill was that of the Stars and Stripes flying beside the Mexican tricolor above the office and chemical laboratory, which had been installed by the company on account of the distance the operations were from any established laboratory. Two diamond drills, a shaft, and a number of drifts are utilized to prove the amount and quality of coal obtainable.

After visiting the workings at Mina Consuelo, a start for the railroad

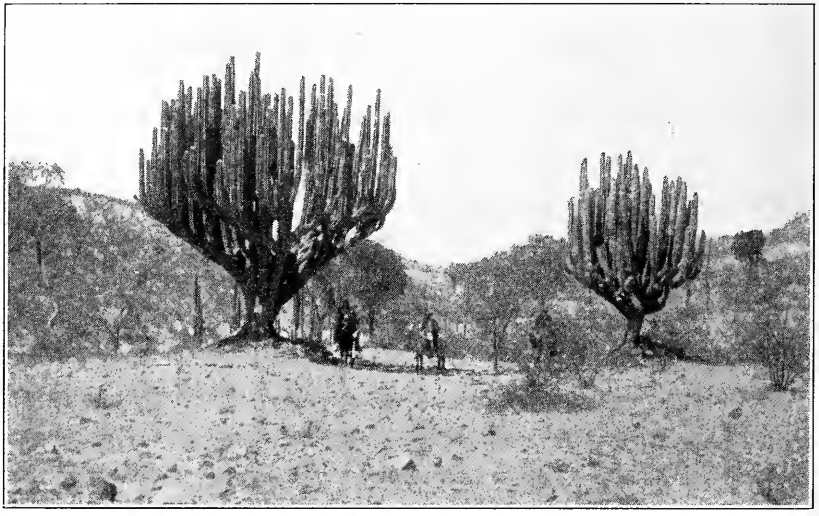

FIG. 9.—Organ cactus (candelabra) trees along the trail in western Oaxaca.

was made, and the character of the vegetation changed. Banana and palm trees were seen, fields of sugar-cane were passed, and occasionally the trail, which passed through innumerable palmettos, was left for the welcome shade of large trees of candelabra cactus, which have a pulpy trunk supporting a number of branches, forming a tree about thirty feet high with a spread of the same distance.

Passing through Huajuapam de Leon, a town next in importance to Tlaxiaco, a stop for the night was made at Chila, a little pueblo, where early in the morning the soft plaintive music of an orchestra was heard,

growing louder as from a nearby church came a funeral procession. A number of women and children, each with a small bouquet, preceded the chief mourners and the coffin, which was borne on the shoulders of men, who also carried flowers, and followed by the orchestra. Even the musicians carried small bunches of flowers, those playing the violin and 'cello holding them in the hand with the bow, and on account of the length of his instrument the player of the 'cello had its base supported by an assistant, while he played with its stem resting upon his shoulder.

Continuing the journey and obtaining beautiful views of the moun-

Fig. 10.—Wagon road ascending mountain face near Acatlan, Puebla; average grade about ten per cent.

tain ranges and valleys from among the palmettos, which grew either close to the ground or as the stems of branching trees, the town of Acatlan was reached. Here the horses were reluctantly left behind, and seats were taken in a coach which five mules, urged by a "mozo" riding a sixth, pulled over the mountain on a steep, winding road made by cutting into the hillside and filling in back of retaining walls of masonry and overcoming an elevation of 2,500 feet in five miles. Although the wheels of the vehicle were so loose on their axles that a breakdown seemed imminent and inevitable, especially when the mules were driven at a gallop down the mountain side, a safe arrival was made at Mucio

Martínez, the terminus of the "Ferrocarril de San Marcus y Huajuapam de Leon," a railroad which connects at Rosendo Márquez with the Mexican Southern Railroad to Pueblo, but does not touch either of the towns named in its title. During the latter part of the ride the discomforts of the coach were forgotten in the enjoyment of a view the blue sky-line of which was broken by the peak of Malenchi and the snow caps of Popocatepetl, Ixtaccihuatl, and Orizaba.

The Birkinbine Engineering Offices

ODD FELLOWS TEMPLE
PHILADELPHIA, PENNA.

Invite attention to their facilities for carrying forward engineering investigations and constructions, including consultations, the preparation of plans, specifications, estimates, tests, reports upon properties or processes and expert testimony.

The specialties for which these offices are equipped include:—

Investigation of mineral deposits, means for developing the same, and for beneficiating and utilizing the minerals.

Design, construction and remodelling of blast furnaces and other metallurgical plants.

Development and improvement of water powers and methods of their utilization.

Drainage, stream control, irrigation and reclamation projects.

Installation of water supplies for municipalities and industries.

Arbitration of disputed cases requiring engineering experience, or the investigation and valuation of properties or processes offered for investment.

Expert engineering testimony in litigations.

The Birkinbine Engineering Offices claim as endorsements: the record of a business life covering more than half a century, in which three generations have participated; the wide range of work planned and executed in this and other countries; and the policy of keeping free from financial interests, contingent fees or patent royalties.

JOHN BIRKINBINE C. P. BIRKINBINE
F. L. BITLER H. E. BIRKINBINE
J. L. W. BIRKINBINE
MUTUAL LIFE BUILDING, CITY OF MEXICO